Director, Operational Test and Evaluation

Handheld, Manpack, Small Form Fit (HMS) AN/PRC-155 Manpack Radio and Joint Enterprise Network Manager (JENM)

Follow-on Operational Test and Evaluation

December 2014

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Director

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
01 DEC 2014	**N/A**	**-**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
Hanheld, Manpack, Small Form Fit (HMS) AN/PRC-155 Manpack Radio and Joint Enterprise Network Manager (JENM) Follow-on Operational Test and Evaluation (FOT&E) Report	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Director, Operational Test and Evaluation (DOT&E) 1700 Defense Pentagon Room 3E1088 Washington, DC 20301**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release, distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			
unclassified	**unclassified**	**unclassified**	**SAR**	**35**	

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Executive Summary

This report provides my operational assessment of the Handheld, Manpack, Small Form Fit (HMS) AN/PRC-155 Manpack radio and Joint Enterprise Network Manager (JENM). It is based on the results of the Manpack radio Follow-on Operational Test and Evaluation (FOT&E) the Army Test and Evaluation Command (ATEC) conducted at White Sands Missile Range, New Mexico, and Fort Bliss, Texas, in May 2014. This assessment is augmented by the results of Government Developmental Test (GDT) 4 conducted from January through February 2014, at Fort Huachuca, Arizona.

Operational Effectiveness

The Manpack radio was not operationally effective when employed in dismounted operations during the FOT&E. This assessment is the result of the Soldier Radio Waveform (SRW) not providing sufficient range to support dismounted company- and platoon-level operations. The use of SRW on the Manpack radio for voice communications degrades a unit's capability to exercise command and control, in comparison to currently fielded radios operating with the Single Channel Ground and Airborne Radio System (SINCGARS) waveform. The Manpack radio was operationally effective for mounted operations. Vehicular-mounted Manpack radios mitigated SRW range limitations due to higher vehicle-mounted antennas. Additionally, the mounted test unit had a higher density of Manpack radios, and hence a denser network, aiding communications in comparison to the dismounted test unit.

Dismounted Operations

At company and platoon level, voice communications are the primary and most critical means for tactical leaders to exercise mission command. Impaired voice communications adversely affect the ability of a platoon or company to successfully execute its tactical mission.

During the FOT&E, units operating dismounted radios were not able to maintain reliable voice communications using SRW due to the waveform's inherent range limitations. Units employing SRW voice communications will have a reduced point-to-point range in comparison to the legacy SINCGARS Advanced System Improvement Program (ASIP) radios. This outcome is directly explainable by the physics of waveforms. Higher frequency waveforms have a shorter range than lower frequency waveforms and are more affected by terrain obstructions. During the FOT&E, the company network operated on the Ultra-High Frequency (UHF) band and the platoon networks on L-band. Both of these bands are higher frequency than SINCGARS, which operates in the Very-High Frequency (VHF) band.

During the final FOT&E focus group discussion, all three infantry rifle company commanders, along with all eight unit radio operators present, stated they would not want to take the Manpack radio to combat. The main reason the commanders gave was the inability to communicate by voice with subordinate units. The cavalry troop commander stated in his focus group, *"It is harder to communicate in this unit [in comparison to his unit in Afghanistan] and I blame SRW."*

Mounted Operations

During the FOT&E, the Manpack radio was operationally effective for mounted operations. The cavalry troop predominately operated the mounted radios and the SRW network performed satisfactorily in their vehicles. This was the result of three principal factors. First, vehicular-mounted Manpack radios mitigated SRW range limitations due to higher vehicle-mounted antennas. Having a taller antenna enabled the radio transmissions to more easily overcome the micro-terrain that hampered the dismounted Manpack radio operators. Second, the mounted test unit had a higher density of Manpack radios, and hence a denser network, aiding communications in comparison to the dismounted test unit. Third, the cavalry troop operated in less restricted terrain than did the three infantry companies. Nevertheless, physics still dictates that SRW will have a shorter range and be more sensitive to terrain obstructions than the SINCGARS waveform.

Single Channel Ground and Airborne Radio System (SINCGARS) Waveform

During the FOT&E, SINCGARS waveform performance on the Manpack radio improved from that demonstrated in the Manpack radio Multi-Service Operational Test and Evaluation (MOT&E) in 2012, where DOT&E evaluated it as not operationally effective. During the FOT&E, there were no observed issues with the Manpack radio's SINCGARS range or connectivity.

Satellite Communications (SATCOM) Waveforms

The FOT&E was not adequate to evaluate the effectiveness of the three satellite communications (SATCOM) waveforms operating on the Manpack radio. Due to satellite availability, each of the SATCOM waveforms (181B, 182A, and 183A) was available for only one, 72-hour window. As a result, there were insufficient SATCOM operating hours for an adequate evaluation. Additionally, the unit had difficulty connecting to the satellite with all three SATCOM waveforms. The source of this connectivity problem is not known; the numerous failures to connect to the satellite may have been due to the unit being assigned a lower priority than other users of the same satellite. A lower priority would deny the Manpack radio operator access to the satellite if higher-priority users were using the SATCOM channel.

Two Channel Operations

The ability of the Manpack radio to simultaneously operate on two channels worked well and was noted as positive by the Soldiers in the FOT&E. In normal operations, a Manpack radio operator could have one channel on his unit network and the other channel on an alternate network to obtain a simultaneous connection. This ability to have two channels in one radio is valuable to leaders and operators who may need to operate on two different networks.

Multiple Waveforms

The Manpack radio is a software-defined radio that can operate five different waveforms. Having multiple waveforms available on a single radio enhances a unit's flexibility. During the FOT&E, the capability to switch between different waveforms enhanced unit operations.

Joint Enterprise Network Manager (JENM)

The JENM was able to plan, configure, and load all necessary configuration files into the Manpack radios used in the FOT&E. The JENM operated as intended and had the necessary capability to perform these functions. However, the process for planning a network is cumbersome and the time to load all of the Manpack and Rifleman Radios in a unit is excessive, taking as long as 24 hours for a single company.

Operational Suitability

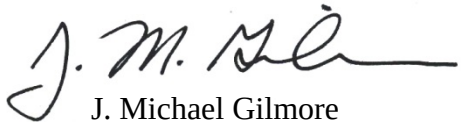
The Manpack radio is not operationally suitable. The weight of the radio with a 24-hour load of batteries is three times the legacy ASIP radio. This increase is not acceptable for dismounted operations and is a burden to the Soldiers carrying the radio. The reliability of the Manpack radio has improved from what was measured in the MOT&E and is assessed as reliable for the Soldier Radio Waveform (SRW). Although the SINCGARS waveform did not meet its reliability requirement, its reliability did not adversely affect the test unit's ability to execute the mission. The SATCOM waveform 183A did not meet its reliability requirement. The reliability of the satellite SATCOM waveforms 181B and 182A cannot be determined due to insufficient operating hours.

The heat given off by the Manpack radio is within the Military Standard for safe operations, but made several of the operators uncomfortable. The training was good for most operators, but leaders needed more instruction on how to employ an SRW network in their unit's concept of operations.

The JENM training was satisfactory. It included classroom time and a practical exercise where new users planned and loaded the configuration files for each type of radio supplied to their respective units.

Survivability

The Manpack radio is not survivable in its current configuration. The Army Research Laboratory Survivability/Lethality Analysis Directorate (ARL/SLAD) conducted a Step 4, cooperative analysis of the Manpack radio and SRW network. The Army's Threat Systems Management Office, with assistance from ARL/SLAD, led a Step 5, adversarial assessment. The Threat Systems Management Office conducted electronic warfare via communications jamming of the SRW radios and unreliability jamming. The complete survivability evaluation is contained in the classified annex.



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Section One
System Overview

This report provides an operational assessment of the Handheld, Manpack, Small Form Fit (HMS) AN/PRC-155 Manpack radio and Joint Enterprise Network Manager (JENM). It is based on the results of the Manpack radio Follow-on Operational Test and Evaluation (FOT&E) the Army Test and Evaluation Command (ATEC) conducted at White Sands Missile Range, New Mexico, and Fort Bliss, Texas, in May 2014. This assessment is augmented by the results of Government Developmental Test (GDT) 4 conducted from January through February 2014, at Fort Huachuca, Arizona.

System Description

HMS Manpack

The HMS Manpack radio is a two-channel, software-defined radio capable of simultaneous transmission of voice and data communications. The Manpack radio has an operating frequency from 2 to 512 Megahertz with a 20-watt power output and 512 Megahertz to 2.5 Gigahertz with a 10-watt power output. It can be configured to be carried by a Soldier, mounted in a vehicle, or for static-base station operations. The radio is shown in Figure 1-1 and includes:

- Two-channel receiver/transmitter
- Battery bucket
- Antennas (varied by frequency range)
  - Very-High Frequency (VHF) Single Channel Ground and Airborne Radio System ((SINCGARS))
  - Two multiband (Ultra-High Frequency (UHF) and L-band)
  - Satellite Communications (SATCOM) (181B, 182A, and 183A)
- Power amplifier for each channel
- Interface display

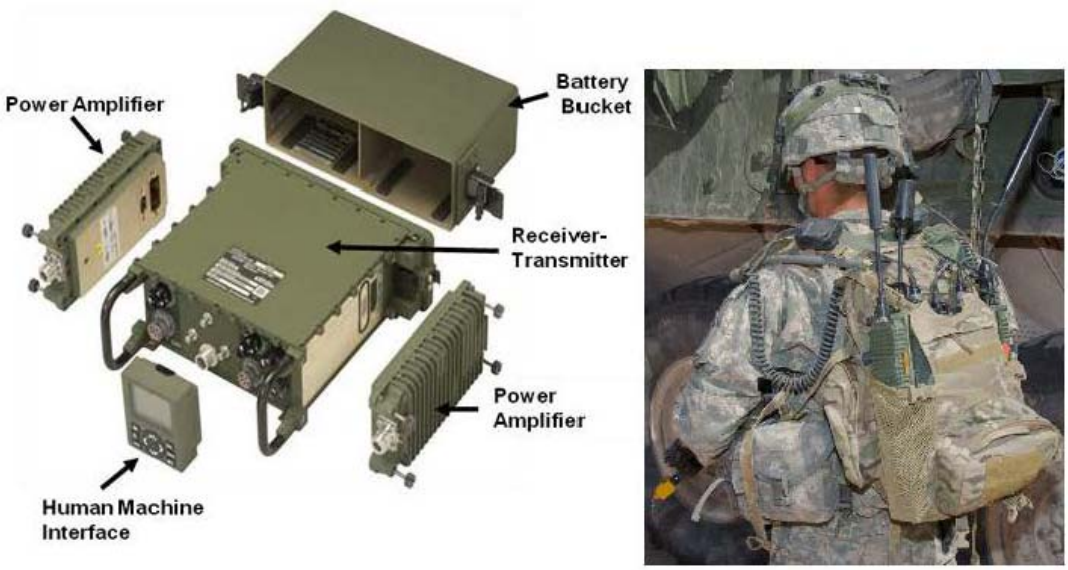

Figure 1-1. HMS Manpack radio components (left) and a Soldier carrying the radio in a dismounted configuration (right)

As tested in the FOT&E, the Manpack hosted and used five waveforms:

- Soldier Radio Waveform (SRW)
- SINCGARS
- UHF-SATCOM 181B, 182A, and 183A

During the FOT&E, Soldiers used the Manpack radios for:

- Data transmission within and between the platoon and company nets;
- Data connection with the Joint Battle Command – Platform (JBC-P) mission command system to connect the JBC-P data to the SRW networks' data;
- Voice communications using the SRW at the company and platoon levels;
- Voice communications using the SINCGARS waveform on the battalion network
- Voice communications using the UHF-SATCOM waveforms when units operated outside of the range of terrestrial communications.

Figure 1-2. HMS Manpack Radio in Vehicle-mounted Configuration

Joint Enterprise Network Manager (JENM)

The JENM is a software application that runs on the Joint Tactical Networking-Environment Network-Operations Toolkit laptop. The JENM performs three functions: networking planning, loading configuration files, and network monitoring. Soldiers use the JENM to create the configuration files for the networking radios and then load those files onto the radios. The monitoring function consists of a JENM using a networking radio to monitor the status of the SRW network. JENM software version 1.2.8.1 was used during the FOT&E.

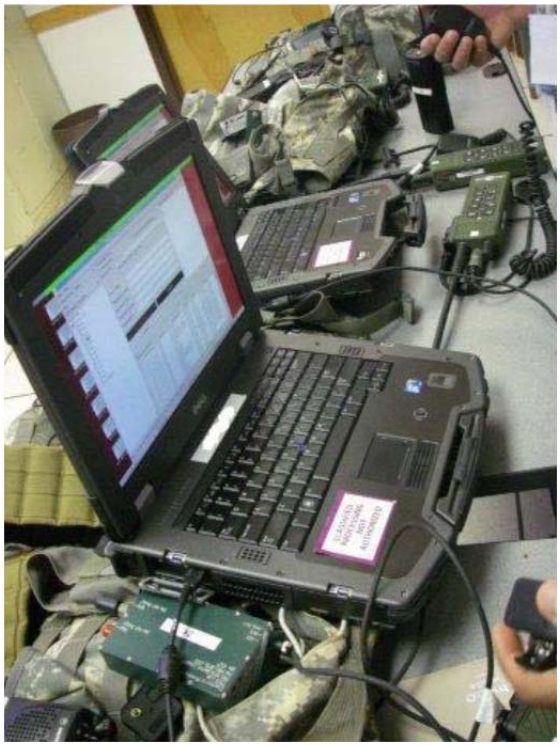

Figure 1-2. JENM application running on a Joint Tactical Networking-Environment Network-Operations Toolkit (JTNT) Laptop

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Section Two
Test Adequacy

The Army Test and Evaluation Command (ATEC) executed the Manpack radio Follow-on Operational Test and Evaluation (FOT&E) in accordance with the Director, Operational Test and Evaluation (DOT&E)-approved test plan. The FOT&E provided sufficient data to support an evaluation of the operational effectiveness, suitability, and survivability of the Manpack radio and the Joint Enterprise Network Manager (JENM).

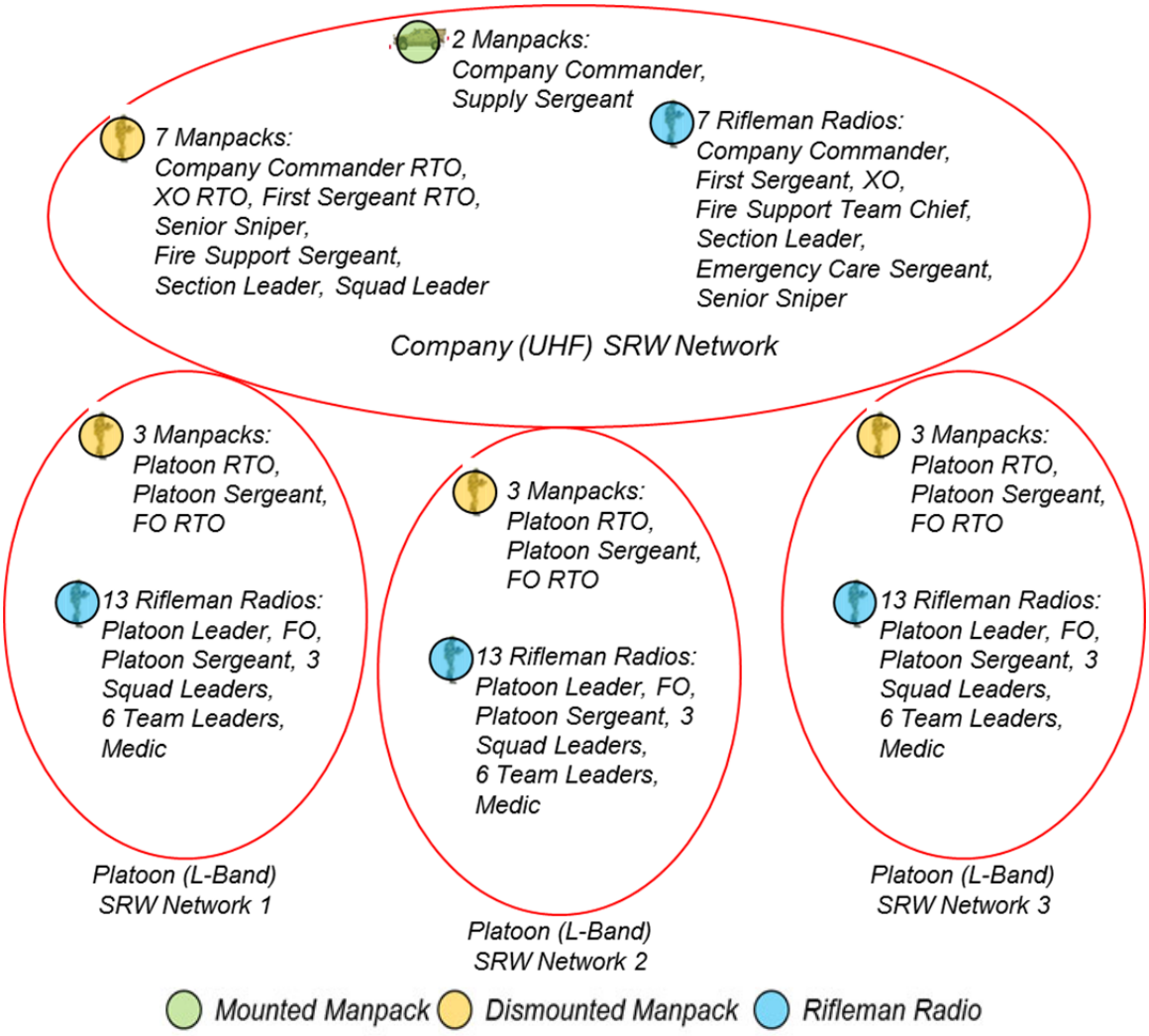
Test Scope

ATEC conducted the Manpack radio FOT&E from April 28 through May 17, 2014, at Fort Bliss, Texas, and White Sands Missile Range, New Mexico; the pilot test from April 28 through May 3, 2014 (in order to confirm appropriate test procedures were in place); and the record test from May 6 – 17, 2014. During the FOT&E, ATEC collected manual and instrumented data, Soldier interviews, and focus group discussions. The JENM was evaluated during the Manpack FOT&E and during pretest planning and loading activities.

The FOT&E test units consisted of a Stryker infantry battalion and a cavalry troop mounted in Mine-Resistant Ambush Protected vehicles. During the FOT&E, test units conducted offensive and defensive missions against an enemy threat consisting of conventional forces, paramilitary forces, and insurgents in three, 72-hour scenarios.

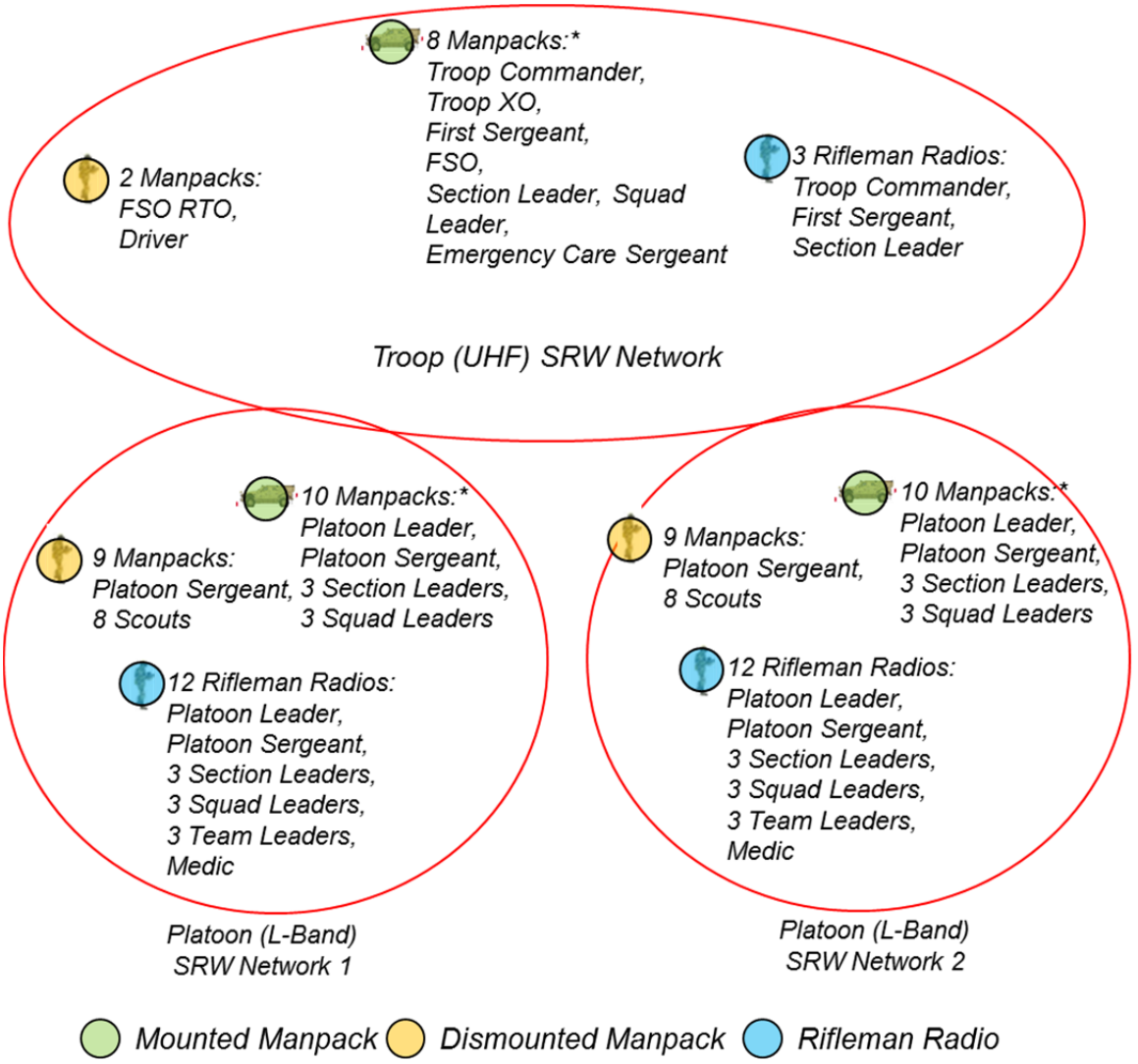
The Stryker battalion was equipped with 45 dismounted and 6 mounted Manpack radios, 1 Tactical Operations Center kit, and 4 JENMs. The Manpack radios were located in the battalion headquarters and the three rifle companies conducted predominately dismounted operations. The infantry rifle company's radio architecture is depicted in Figure 2-1.

The cavalry troop was composed of a troop headquarters and two platoons. The troop was equipped with 18 dismounted Manpack radios, 28 mounted Manpack radios, and 2 JENMs. The cavalry troop conducted primarily mounted operations. The cavalry troop's radio architecture is depicted in Figure 2-2.



RTO – Radio Telephone Operator ; FO – Forward Observer; XO – Executive Officer; UHF – Ultra-High Frequency; SRW – Soldier Radio Waveform

Figure 2-1. Infantry Rifle Company Architecture



RTO – Radio Telephone Operator; FSO – Fire Support Officer; XO – Executive Officer; UHF – Ultra-High Frequency;
SRW – Soldier Radio Waveform

Figure 2-2. Cavalry Troop Architecture

Test Limitations

- The dismounted Manpack radios were not instrumented as ATEC currently has no functional instrumentation for dismounted radios. As a result, message traffic from, to, or through dismounted Manpack radios was not recorded. This limits DOT&E's ability to assess the message completion rates and radio transmission ranges for the dismounted SRW networks. A majority of the Manpack radios (15 of 17) in the infantry rifle companies were in the dismounted configuration.
- The messages in the instrumented database are point-to-point messages. Only mounted radios were instrumented. Therefore, it is not possible to track a message as it "hops" from radio to radio. The instrumentation only records whether a message

was completed with direct line-of-sight, not if a message was networked through another radio as would often be the case in an SRW network. This limits our understanding of how the radios routed messages through the network.

- The test unit had limited access to communications satellites, which limited the number of hours available for use with the Manpack radio's SATCOM waveform. This limitation adversely affected the evaluation of the SATCOM waveforms.

Despite the limitations noted above, DOT&E was able to conduct an evaluation of Manpack radio operational effectiveness in support of dismounted operations. In-depth focus groups with leaders and Soldiers, Soldier and evaluator observations, and survey data provided sufficient information to reach an assessment of SRW performance. Soldier feedback with respect to SRW range is consistent with the physics of SRW.

Section Three
Operational Effectiveness

The Handheld, Manpack, Small Form Fit (HMS) Manpack radio was not operationally effective when employed in dismounted operations during the FOT&E. This assessment is the result of the Soldier Radio Waveform (SRW) not providing sufficient range to support dismounted company and platoon-level operations. The use of SRW on the Manpack radio for voice communications degrades a unit's capability to exercise command and control, in comparison to currently fielded radios operating with the Single Channel Ground and Airborne Radio System (SINCGARS) waveform. The Manpack was operationally effective for mounted operations. Vehicular-mounted Manpack radios mitigated SRW range limitations due to higher vehicle-mounted antennas. Additionally, the mounted test unit had a higher density of Manpack radios, and hence a denser network, aiding communications in comparison to the dismounted test unit.

The Joint Enterprise Network Manager (JENM) was able to plan, configure, and load all necessary configuration files into the Manpack radios used in the FOT&E. The JENM operated as intended and had the necessary capability to perform these functions. However, the process for planning a network is cumbersome and the time to load all of the Manpack and Rifleman Radios in a unit is excessive, taking as long as 24 hours for a single company.

HMS Manpack

The Army intends the Manpack radio to enhance a unit's ability to accomplish its mission by providing the ability to transmit voice and data traffic (including position location information (PLI)) from dismounted Soldiers using multiple line-of-sight and satellite waveforms. At the company and platoon level, SRW is the designated waveform to carry voice and data. The company and platoon SRW networks consist of both Manpack and Rifleman Radios. The SINCGARS waveform is used for voice communications at the battalion level. Satellite communications (SATCOM) waveforms would be used under circumstances when the Manpack radio is outside of SINCGARS-planning ranges (40 kilometers maximum) and the equipped unit has allocated access to satellites for voice communications.

SRW Voice Communications

Dismounted Operations

At company and platoon level, voice communications are the primary and most critical means for tactical leaders to exercise mission command. Impaired voice communications adversely affect the ability of a platoon or company to successfully execute its tactical mission.

During the FOT&E, units operating dismounted radios were not able to maintain reliable voice communications using SRW due to the waveform's inherent range limitations. Units employing SRW voice communications will have a reduced point-to-point range in comparison to the legacy SINCGARS Advanced System Improvement Program (ASIP) radios. This outcome is directly explainable by the physics of waveforms. Higher frequency waveforms have a shorter range than lower frequency waveforms and are more affected by terrain obstructions.

Table 3-1 lists the frequency bands for the terrestrial waveforms used by the Manpack radio. During the FOT&E, the company network operated on the Ultra-High Frequency (UHF) band and the platoon networks on L-band.

Table 3-1. Waveform Frequency Comparison

Waveform	Frequency Band	Frequency	Wavelength
SINCGARS	VHF	30 – 88 MHz	10 – 3.4 m
SRW	UHF	225-400 MHz	1.3 – 0.7 m
	L-band	1350-1390 and 1755-1850 MHz	0.22 – 0.16 m

SINCGARS – Single Channel Ground Airborne System; SRW – Soldier Radio Waveform; VHF – Very-High Frequency; UHF – Ultra-High Frequency

The range of a transmission is dependent on how much power is available to the receiver of a transmission. The simplest measure of power available at a receiver is free space path loss, or the loss of power through unobstructed space. Figure 3-1 shows the free space path loss for each frequency band as a function of distance, and the corresponding power loss for each frequency band over distance. Every three decibels of loss halves the received power. These charts show that the lower frequencies will have a higher received power at distance compared to higher frequencies. For example, the difference in received power between Very-High Frequency (VHF) and L-band is approximately four orders of magnitude. As a result, SRW range in either the UHF band or L-band is inherently shorter than that of SINCGARS operating in the VHF band.

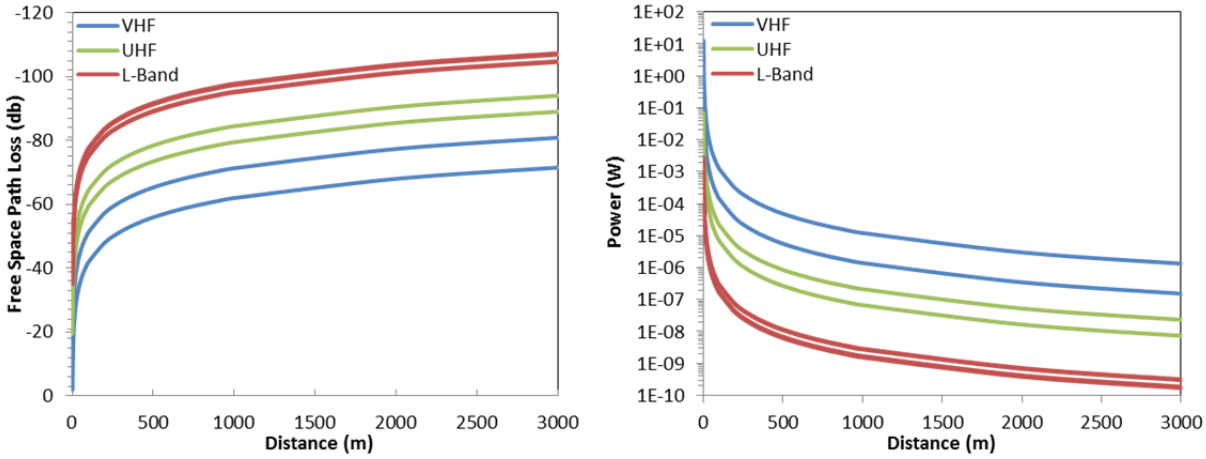


Figure 3-1. Free Space Path Loss and Power at Distance for Frequency Bands

The operational concept for a tactical network of Manpack and Rifleman Radios running SRW assumes that SRW-equipped radios would establish a network where all voice and data could be routed to any radio in that network. This differs from traditional radio communications, such as SINCGARS radios on the VHF band, which only transmit point-to-point. The routing of voice and data through the various radio nodes in the SRW network theoretically would allow calls and messages to route around terrain obstacles, enabling communications over longer distances than would be the case with point-to-point communications. With this concept, the

shorter range and increased sensitivity to terrain obstacles of SRW would be overcome by its capability to network radios (i.e., the capability of voice and data to hop from radio to radio).

During the FOT&E, this operational concept did not provide effective tactical communications at the company and platoon level, particularly for dismounted operations. In order to be successful, a network must have a sufficient number of radio nodes and these nodes must be placed in such a manner as to account for each terrain feature and SRW range limitations. Neither of these conditions was met during the FOT&E. There are not enough radio nodes in a dismounted infantry company to establish a consistently reliable network and overcome terrain and range limitations at either company or platoon level. As unit leaders and radio operators noted, they found themselves having to place the Manpack radios in tactically-exposed positions in order to overcome terrain effects and establish the line-of-sight necessary to communicate with other radios. During the FOT&E, the SRW network was not able to overcome SRW range limitations.

During the FOT&E, both unit leaders and Manpack radio operators noted the range shortcomings of SRW when conducting dismounted operations. The three infantry company commanders stated they had difficulty communicating with their platoons over the SRW network and that minor-terrain features obstructed communications. Based upon their personal experiences, to include combat operations, the infantry company commanders observed that SINCGARS ASIP radios had superior range. One company commander remarked that during the FOT&E, even minor terrain features disrupted his ability to talk over SRW, while he could talk *"crystal clear"* over the Manpack radio with SINCGARS. Company commanders stated they often reverted to talking to their subordinate units over SINCGARS because they were not able to communicate over SRW. One company commander noted with regards to SRW: *"We're not getting the range as advertised. Micro-terrain is completely eliminating comms or degrading it.*" Another concluded: "*The SRW is completely unreliable voice comms."*

Platoon sergeants and radio operators who were carrying the Manpack radios echoed these observations. They also observed that minor-terrain features frequently blocked SRW transmissions; if the platoon sergeant or radio operator did not have visual line-of-sight with the intended recipient of a transmission, they were not able to establish voice communications over SRW. One platoon sergeant stated when discussing an ambush mission: *"I immediately tried to call our XO [Executive Officer] and there was nothing. When I looked around and saw the terrain, I knew what it was. The SRW has to be line-of-sight and there was no line-of-sight with anyone so it [the Manpack radio] was a dead weight at this point."* Another platoon sergeant commented: *"I had a recon element go 150 meters away over a small hill. As soon as they crested that hill I lost them."* Another platoon sergeant stated: *"It [the Manpack radio with SRW] is forcing us to do tactically unsafe things in order to get communications, like getting on top of a dune just to get communication."*

One Infantry Platoon Sergeant described a situation where there was a 12-meter high terrain obstacle between him and a Soldier he was trying to reach 200 meters away. He stated, *"I knew they were there and it wasn't until I crested that hilltop about 100 meters away and actually had eyes on them I finally reached them on the [Manpack radio]."* Soldiers asserted

during focus groups that they could have overcome these terrain issues if they had been using a SINCGARS ASIP radio instead.

Figure 3-2 models what the interference would have been between the Platoon Sergeant and the intended receiver as a function of frequency.

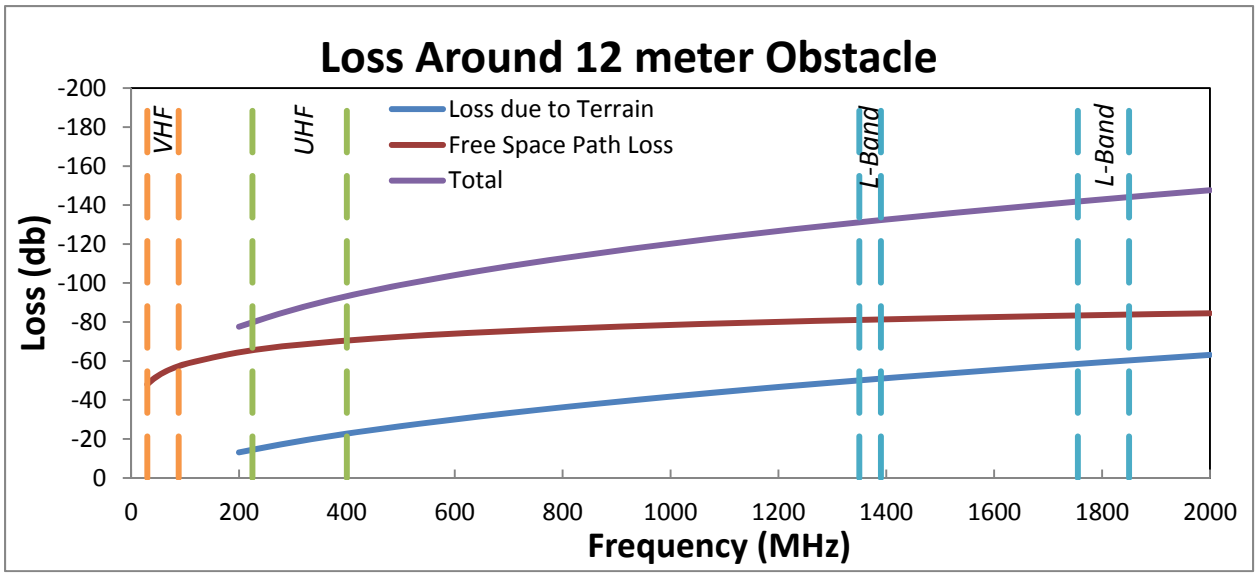


Figure 3-2. Transmission Loss around a Terrain Obstacle

From the model displayed in Figure 3-2, transmissions using frequencies in the VHF range would not have experienced much loss to the terrain and only the free space path loss of -61 decibels (db) is experienced. The loss experienced in the lower of the two L-band frequencies due to free space path loss and the obstacle is -131 db, which is high enough to block those communications. The difference in received power between the VHF and L-band of -70 db is a power difference of, roughly, seven orders of magnitude. This simple model verifies the Platoon Sergeant's assertion that he could not communicate and lends support to other Soldiers' assertions that SINCGARS in the VHF band is much more flexible in terrain than SRW in either UHF or L-band.

Radio operators had similar observations as the platoon sergeants. One radio operator stated: *"In some of these hilly areas, because it's a line-of-sight radio, you could be like 30 meters from your front line trace and have three or four berms in front of you and you can't hear or talk to them [other members of the platoon] at all. I could yell and talk to them but I can't transmit on the radio to them."* Another radio operator commented: *"From the dismounted perspective, when we were in the low ground we couldn't get comms so we would have to expose ourselves to the enemy just to get comms."*

During the final FOT&E focus group discussion, all three infantry rifle company commanders, along with all eight unit radio operators present, stated they would not want to take the Manpack radio to combat. The main reason the commanders gave was the inability to communicate by voice with subordinate units. The cavalry troop commander stated in his focus

group: *"It is harder to communicate in this unit [in comparison to his unit in Afghanistan] and I blame SRW."*

Mounted Operations

During the FOT&E, the Manpack radio was operationally effective for mounted operations. The cavalry troop predominately operated the mounted radios and the SRW network performed satisfactorily in their vehicles. This was the result of three principal factors. First, vehicular-mounted Manpack radios mitigated SRW range limitations due to higher vehicle-mounted antennas. Having a taller antenna enabled the radio transmissions to more easily overcome the micro-terrain that hampered the dismounted Manpack radio operators. Second, as noted in Table 3-2, the mounted test unit had a higher density of Manpack radios, and hence a denser network, aiding communications in comparison to the dismounted test unit. Third, the cavalry troop operated in less restricted terrain than did the three infantry companies. Nevertheless, physics still dictates that SRW will have a shorter range and be more sensitive to terrain obstructions than the SINCGARS waveform.

Table 3-2. Number and Type of Radios for Test Units

Test Unit	Company			Platoon (each)		
	Mounted Manpacks	Dismounted Manpack	Rifleman Radios	Mounted Manpacks	Dismounted Manpack	Rifleman Radios
Mounted Cavalry	8	2	3	10	9	12
Dismounted Infantry	2	7	7	0	3	13

The increased number of mounted Manpack radios enabled units engaged in mounted operations to communicate better than those in dismounted operations. This is highlighted in Table 3-3, which contrasts the interview responses of both cavalry troop and infantry companies members. The cavalry troop's respondents were all mounted operators that conducted mounted missions. The infantry companies included both mounted and dismounted operators and leaders, but all of their missions were dismounted.

Table 3-3. Interview Question Responses

Question	Infantry Companies		Cavalry Troop	
	Yes	No	Yes	No
Was the radio range adequate to support your mission?	42	28	12	0
Do you feel the MP radio enhanced your ability to execute the mission more than your current radio?	25	43	10	1
Is Manpack radio ready to be employed in Combat?	11	59	11	1

Respondents from the cavalry troop were positive about the questions asked in Table 3-2, while the respondents in the infantry companies were either negative or their answers were not statistically significant. This difference in experience is reflective of the number of Manpack

radios and how they were used. Mounted operations with less interference due to terrain and range were much more positively rated than the dismounted operations.

SRW Performance in Previous Testing

Government Developmental Test (GDT 4)

From January through February 2014, the Army conducted Government Developmental Test 4 (GDT 4) at Fort Huachuca, Arizona. During this developmental test event, SRW performed satisfactorily with respect to voice call completion rate, data message completion rate, voice quality, and data speed of service.

GDT 4 did not examine SRW range in a systematic manner nor was SRW evaluated under operational conditions such as existed in the FOT&E. GDT 4 test scenarios were far less challenging than those experienced during the FOT&E. During the test, units largely conducted Manpack radio operations from static positions with good line-of-sight. Dismounted movement under tactical conditions was not conducted. As a result, the SRW range deficiencies and sensitivity to terrain obstruction evident during the FOT&E were not identified during GDT 4.

Manpack Multi-service Operational Test and Evaluation (MOT&E)

The Army conducted the Manpack Multi-service Operational Test and Evaluation (MOT&E) in May 2012 as part of Network Integration Evaluation 12.2. The performance of the SRW on the Manpack radio during the MOT&E was better than the May 2014 FOT&E and was evaluated by DOT&E as being effective during that test event. The difference in SRW performance between these two operational tests is attributable to several factors discussed below.

Table 3-4 lists the differences between the two tests. The larger number of Manpack and Rifleman Radios in the MOT&E unit made for a more robust network with fewer isolated nodes. This enabled better communication within the unit.

Table 3-4. Differences between MOT&E and FOT&E Test Units

	MOT&E	FOT&E
SRW Performance	The SRW performance on the Manpack radio was positive with good voice range and the PLI provided by the SRW network, adding to the situational awareness of leaders.	The SRW performance on the Manpack radio during the FOT&E had poor voice connectivity and the PLI provided little value due to the poor connectivity.
Unit	Mounted Infantry Company	Mounted Cavalry Troop and Dismounted Infantry Companies
Total number of SRW nodes (Rifleman Radios and Manpack radio) per Platoon	40	Cavalry Troop: 29 Infantry Company: 16

SRW – Soldier Radio Waveform; PLI – Position Location Information

During the FOT&E, the reduction in the number of SRW-equipped radios in platoons and the lower number of mounted SRW radios, precluded the Manpack radio from being effective using SRW in dismounted operations.

SRW Data Communications

The ATEC instrumentation plan for the FOT&E did not cover every Manpack radio in the test units. For the FOT&E, there was no dismounted data collection tool for the Manpack radios. Only mounted Manpack radios could be instrumented with the Goldeneye data collection system. The inclusion of the Joint Battle Command – Platform (JBC-P) connection to mounted Manpack radios made the data reduction complicated. Each data message took multiple paths from the sender to the receiver. These paths included the satellite links between JBC-P terminals. The instrumentation did not record the path that each message had taken. Thus, messages traveling over the satellite could not be distinguished from messages that had traveled via the SRW network.

The lack of dismounted Manpack radio instrumentation and the inability to track messages from the sender to the direct receiver precluded DOT&E's ability to assess the dismounted Manpack radios using the instrumented database. Instrumentation could not record messages sent by, received from, or routed through the dismounted Manpack radios. Thus, the instrumented database does not fully and accurately describe the SRW network as it was implemented in the FOT&E.

Single Channel Ground and Airborne Radio System (SINCGARS) Waveform

During the FOT&E, SINCGARS waveform performance on the Manpack radio improved from that demonstrated in the Manpack radio MOT&E in 2012, where DOT&E evaluated it as not operationally effective. During the FOT&E, there were no observed issues with the Manpack radio's SINCGARS range or connectivity.

There is some evidence that the range of the SINCGARS on the Manpack radio is shorter than that of the SINCGARS on the legacy ASIP radio. The power amplifier on the Manpack radio has a maximum output of 20 Watts, while the ASIP emits at 50 Watts, leading to a longer range for the ASIP signal. Infantry Manpack radio operators observed shorter range with the Manpack radio SINCGARS and noted that the voice volume was often too low to be understood. During the FOT&E, if Soldiers could not communicate with the intended receiver using the mounted Manpack radio, they often reverted to mounted SINCGARS ASIPs to successfully complete the call. During the final focus group of the FOT&E, one company commander commented, *"[The Manpack radio] has not gotten to the point where it could replace the ASIP. We know right now [that] it hasn't caught up to and passed the ASIP in terms of reliability, range, or clarity of communications to where it's a better option."*

Table 3-5 shows comparison testing between a SINCGARS ASIP and a Manpack radio with SINCGARS during GDT 4. At a 10-klilometer range, while the voice quality was lower for the Manpack radio than the ASIP, it was still sufficient to score the calls as good (a voice call scored by the receiver as 3 or higher, on a scale of 1-5, is considered a completed call). However, at a 40-kilometer range, the voice quality and call completion rate for the Manpack

radio were notably lower than those for the ASIP. This is indicative of the shorter range of the Manpack radio SINCGARS versus that of the ASIP over longer distances.

Table 3-6. SINCGARS GDT 4 Test Results

Distance (km)	ASIP		Manpack	
	Call Completion Rate	Voice Quality Score	Call Completion Rate	Voice Quality Score
10	96.25	4.41	96.30	3.59
40	98.75	3.70	69.38	2.70

SINCGARS – Single Channel Ground and Airborne Radio System; GDT – Government Developmental Test

During the FOT&E, the infantry companies' users and leaders reported that the Manpack radio and legacy SINCGARS ASIP did not interoperate well. During focus groups, five Soldiers reported the same problem of the ASIPs receiving the Manpack radio transmissions and not being able to be heard when responding. Manpack radio operators could discern the ASIP operator keying the microphone but could not hear anything else. When a Soldier realized he had a good connection, he made a long continuous call with all of the information for the receiver, instead of taking the chance that the connection would break when he let go of the microphone button.

Satellite Communications (SATCOM) Waveforms

The FOT&E was not adequate to evaluate the effectiveness of the three SATCOM waveforms operating on the Manpack radio. Due to satellite availability, each of the SATCOM waveforms (181B, 182A, and 183A) was available for only one, 72-hour window. As a result, there were insufficient SATCOM operating hours for an adequate evaluation. Additionally, the unit had difficulty connecting to the satellite with all three SATCOM waveforms. The source of this connectivity problem is not known; the numerous failures to connect to the satellite may have been due to the unit being assigned a lower priority than other users of the same satellite. A lower priority would deny the Manpack radio operator access to the satellite if higher-priority users were using the SATCOM channel. During GDT 4, the SATCOM waveforms performed satisfactorily on the Manpack radio.

Hardware Performance

Two Channel Operations

The ability of the Manpack radio to simultaneously operate on two channels worked well and was noted as positive by the Soldiers in the FOT&E. In normal operations, a Manpack radio operator could have one channel on his unit network and the other channel on an alternate network to obtain a simultaneous connection. This ability to have two channels in one radio is valuable to leaders and operators who may need to operate on two different networks. Eighty percent of interviewed operators and leaders responded that having two channels increased situational awareness. The cavalry troop executive officer thought this was positive by saying, "*I think it's [the Manpack radio] helpful because one radio has two channels on it. It's basically like having two radios. I can pay attention to what's going on at the troop level and the platoon*

level. I can pick one of the platoons at least to listen in on their net[work]. So it gives us better situational awareness in that regard."

Multiple Waveforms

The Manpack radio is a software-defined radio that can operate five different waveforms. Having multiple waveforms available on a single radio enhances a unit's flexibility. During the FOT&E, the capability to switch between different waveforms enhanced unit operations. For example, the dismounted infantry operators often used this feature to switch from an SRW on the company command network to SINCGARS in order to communicate to the unit's Stryker vehicles. Additionally, the availability of SATCOM waveforms offers the opportunity for units to communicate over extended ranges. This flexibility does not exist with legacy radios, each of which run only a single waveform.

Route and Retransmit Function

The Manpack radio is able to transfer voice or data from one channel to the other. For example, this feature routes the PLI on the platoon SRW networks to the company network and vice versa. This allows the platoon leaders to see the PLI of adjacent platoons and a company commander to quickly see the location of all of his units equipped with either a Manpack radio or Rifleman Radio. This was the first operational test of the Manpack radio where route and retransmit function was available for use and worked well. As long as the Manpack radios had connectivity to the wider SRW network, the company commanders had access to PLI from their subordinate units.

Joint Enterprise Network Manager (JENM)

During the FOT&E, the test unit satisfactorily used JENM to plan the SRW network and load the plan onto the SRW-equipped radios. Although JENM operated as intended, there are a number of operational challenges units encounter using JENM. The process for planning a network is cumbersome and the time to load all of the Manpack and Rifleman Radios in a unit is excessive.

JENM does not provide the test unit an adequate capability to support rapid task re-organizations because of the length of time it takes to change the radio presets to match the task re-organization. Operational units frequently change task organizations to tailor for tactical missions and the process to update the networks to accommodate a new unit task organization is lengthy and burdensome. The test unit mitigated this problem during the FOT&E by planning and loading all 50 presets on each channel of the Manpack radio. This allowed the units to be more flexible, but it created a more complicated planning process and added length to the loading time because of the increased number of configuration files that needed to be loaded onto each Manpack radio.

Each unit is required to change the communications security (COMSEC) keys monthly to maintain a secure network. The SRW configuration files contain a key tag that corresponds to a specific security key. Each time the COMSEC keys changeover, a radio must be reloaded with all of the configuration files and keys. This constitutes a complete reload of all SRW-enabled radios in every unit, every month, by the JENM. The cavalry troop signal officer described the

COMSEC changeover during the FOT&E as “an emotional event,” taking the battalion 24 hours to complete. Each radio must be cabled to a JENM or secure key loader (which is first loaded by a JENM) to load the files. This requires that a small team of Soldiers touch each radio before it can be brought back up into the network. The Soldiers responsible for the changeover and the leaders who rely on the radios found the time required to be excessive while they are in the midst of operations. The monitoring function of the JENM is of limited operational utility and provides little information of tactical value. The JENM must be connected to a Manpack radio to monitor the SRW network. Even when connected, the JENM can then only monitor those radios in the same network as that Manpack radio. The only JENMs available for this use during the FOT&E were at the battalion tactical operations center and generally too far away from the company’s SRW networks to monitor any networks. Furthermore, there are no Soldiers assigned to the unit with the task of monitoring the network. The JENM at the company level would be close enough to monitor the SRW networks, but it does not have a dedicated Manpack radio to use for monitoring, or a Soldier assigned to monitor the network. Given the limited utility of the JENM monitoring function, test units chose not to reassign Soldiers from other tasks to monitor the SRW network.

Section Four
Operational Suitability

The Manpack radio is not operationally suitable. The weight of the radio with a 24-hour load of batteries is three times the legacy Advanced System Improvement Program (ASIP) radio. This increase is not acceptable for dismounted operations and is a burden to the Soldiers carrying the radio. The reliability of the Manpack radio has improved from what was measured in the Multi-service Operational Test and Evaluation (MOT&E) and is assessed as reliable for the Soldier Radio Waveform (SRW). Although the Single Channel Ground Airborne Radio System (SINCGARS) waveform did not meet its reliability requirement, its reliability did not adversely affect the test unit's ability to execute the mission. The satellite communications (SATCOM) waveform 183A did not meet its reliability requirement. The reliability of the satellite SATCOM waveforms 181B and 182A cannot be determined due to insufficient operating hours and failures.

The heat given off by the Manpack radio is within the Military Standard for safe operations, but made several of the operators uncomfortable. The training was good for most operators, but leaders needed more instruction on how to employ an SRW network in their unit's concept of operations.

Manpack Radios

Reliability, Availability, and Maintainability

Reliability

The Manpack's Capability Product Document lists its reliability requirement as 477 hours Mean Time Between Essential Function Failure (MTBEFF) for each channel of the Manpack radio. This translates to an 86 percent chance of completing a 72-hour mission without an EFF. Given that both channels are identical, there is no reason to believe that their performance would differ and FOT&E results indicate there is no statistical difference between the reliability of the two channels.

A more appropriate measure of reliability for the Manpack radio is to measure the reliability of each of the waveforms employed on the radio. Both channel and waveform reliability results are presented in Table 4-1.

Table 4-1. Manpack Radio Reliability by Channel and Waveform

	Operating Hours	EFFs	MTBEFF Point Estimate (hours)	MTBEFF 80% Confidence Interval (hours)	Chance of Completing 72-hour mission without an EFF	Requirement (hours)
Channel 1	6745.8	18	375	(272-526)	82.5 %	477
Channel 2	6781.1	15	452	(318-658)	85.3 %	477
Combined	13526.9	33	410	(325-523)	83.9 %	477
SRW	8357.7	14	597	415 - 883	88.6 %	477
SINCGARS	4230.4	14	302	210 - 447	78.8 %	477
181B	129.1	0	--	N/A	--	477
182A	265.0	0	--	N/A	--	477
183A	544.7	5	109	59 - 224	35.2 %	477

SRW – Soldier Radio Waveform; SINCGARS – Single Channel Ground Airborne Radio System; MTBEFF – Mean Time Between Essential Function Failure

During the FOT&E, the SRW demonstrated that it was operationally reliable. Although the SINCGARS waveform fell short of the 477 MTBEFF requirement, its reliability did not adversely affect the test unit's ability to execute the mission.

The SATCOM waveform 183A did not meet its reliability requirement. DOT&E cannot evaluate the reliability of the SATCOM waveforms 181B and 182A. This is due to the limited number of operating hours for these waveforms.

Availability

None of the Manpack radio's channels or waveforms met the Capability Production Document's availability requirement. However, these shortfalls in availability were not operationally significant during the FOT&E. For reasons cited above, SATCOM waveform availability cannot be reliably evaluated. Table 4-2 lists the demonstrated availabilities by channel and waveform.

Table 4-2. Manpack Radio Availability

	Operating Hours	Down Time (Hours)	A_o	Requirement
Channel 1	6745.8	590	0.92	0.96
Channel 2	6781.1	559	0.92	0.96
Combined	13526.9	1149	0.92	0.96
SRW	8357.7	507	0.94	0.96
SINCGARS	4230.4	557	0.88	0.96
181B	129.1	0.3	0.99	0.96
182A	265.0	0.0	1.00	0.96
183A	544.7	84	0.87	0.96

SRW – Soldier Radio Waveform; SINCGARS – Single Channel Ground Airborne Radio System

Maintainability

The Manpack Radio System Support Package, provided by the Handheld, Manpack, Small Form Fit (HMS) Product Office for use in the FOT&E, established a density of two field service representatives (FSRs) for the brigade and two spare Manpack radios per company. The level of field service support was determined as representative of what a brigade would probably experience upon fielding. The Army uses a two-level maintenance concept for the Manpack radio. The first encompasses maintenance actions to be conducted at the unit level, both by the user and the unit signal personnel. The user must troubleshoot the Manpack radio before calling in for organizational support from the signal soldier in the company or battalion signal personnel. The second is support level maintenance work performed by the contractor FSRs who must have the Manpack radio evacuated to them or they must travel from the support battalion to the radio. The demonstrated Mean Time to Repair is shown in Table 4-3. The shortfalls in Mean Time to Repair in comparison to the Capability Production Document requirement demonstrated during the FOT&E were not operationally significant.

Table 4-3. Manpack Radio Maintainability

Level of Maintenance	Maintenance Events	Maintenance Hours	Mean Time to Repair (Hours)	Requirement (Hours)
User	9	3.5	0.4	≤ 0.5
Organization	2	5.3	2.7	≤ 0.5
Field Service Representative (FSR)	2	3.3	1.6	≤ 0.5
Overall	11	12.1	1.10	≤ 0.5

Weight

The Manpack radio is too heavy for dismounted operations. Based upon the battery life demonstrated during the FOT&E, an operator needed to carry four to six batteries in order to

successfully complete a 24-hour mission as compared to one spare battery for the SINCGARS ASIP radio. The total weight of the Manpack radio, to include the radio itself, antennas, and spare batteries, is three times as much as the legacy ASIP radio. The breakdown between the weight carried by an operator using an ASIP and Manpack radio on a 24-hour mission is listed in Table 4-4.

Table 4-4. Breakdown of Manpack Radio and ASIP-Carried Weight

Configuration Item	ASIP		Manpack Radio	
	Number	Weight (lbs.)	Number	Weight (lbs.)
Radio Transmitter	1	4.68	1	10.50
Battery	1	3.04	2	6.08
Hand Microphone	1	0.52	2	1.04
Antennas	1	0.70	5	4.76
Spare Batteries for 24-Hour Mission	1	3.04	4-6	12.16 – 18.24
Total	11.98		34.54 – 40.62	

ASIP – Advanced System Improvement Program

Responses from 75 percent of dismounted operators stated the Manpack radio was too heavy for dismounted operations. An additional aspect of the unfavorable weight was that the Soldiers did not like the program-supplied carrying case. The narrow straps and lack of support were cited during several focus groups as not satisfactory. The Soldiers felt that it did not integrate well with their existing rucksack. This issue was observed in the 2012 MOT&E as well and has not been corrected.

Temperature

Temperature measurements were taken on the Manpack radio's front (face with the control knobs) and side (power amps) during the FOT&E. Soldiers noted that the battery bucket, which is up against the Soldier's back for prolonged periods of time, caused heat discomfort. This temperature was not measured during the FOT&E, but was during the MOT&E. Noting the correlation between the front and back temperature measurements recorded during the MOT&E, one can project what the back temperature measurements were likely to have been in the FOT&E. The recorded measurements and the projected temperature of the back are displayed in Figure 4-1.

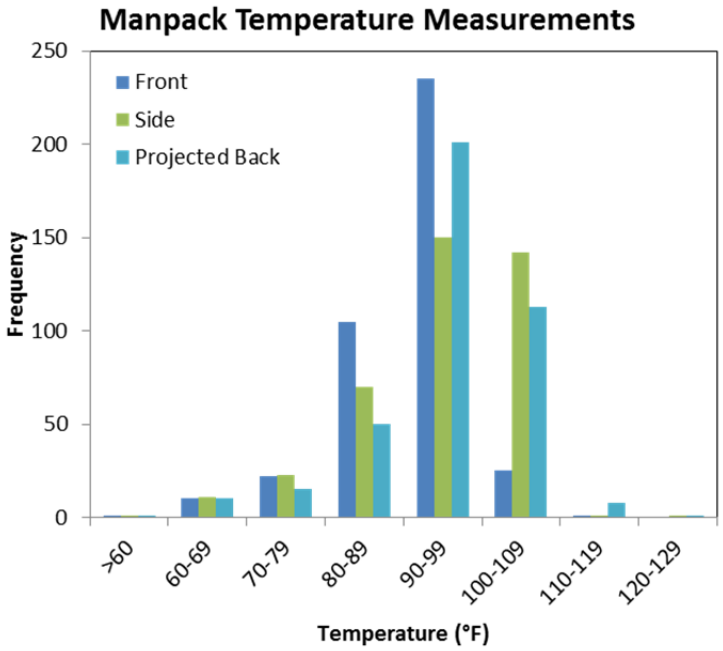


Figure 4-1. Manpack Radio Temperature

Military Standard 1472G states the temperature limit for prolonged exposure to a metal surface is 120 degrees Fahrenheit. During FOT&E, the majority of projected temperatures for the back of the radio were between 90 – 109 degrees Fahrenheit, which is within the Military Standard. However, in focus groups and interviews, numerous Soldiers complained about the heat from the Manpack radio and its discomfort. In 30 out of 66 interview responses, operators stated that they had experienced heat discomfort during the FOT&E. Given the apparent compliance with the Military Standard and operator responses with respect to heat, one can conclude that while the Manpack radio temperature is warm enough to cause discomfort, is not a safety concern.

Training

Training on the use of the basic features of the Manpack radio required of an operator was satisfactory. Soldiers were able to satisfactorily employ the Manpack radio using its switches and Human Machine Interface and reported it easy to use. However, Soldiers were not adequately trained on SATCOM use prior to the FOT&E; they did not receive training until the FOT&E began. Satellite time was not allocated until the pilot phase of the test and the unit did not receive training until that time. Training was conducted several times in the field during the pilot test, but most leaders thought that it was not effective.

There is a lack of training to teach leaders how to effectively employ the Manpack radio in combat operations. It took the infantry companies several FOT&E missions to develop basic tactics, techniques, and procedures for employing the radio. The leaders did not take into consideration the shorter range or networking capability of SRW until the FOT&E had already begun.

JENM Suitability

Training

The JENM training was satisfactory. It included classroom time and a practical exercise where new users planned and loaded the configuration files for each type of radio supplied to their respective units.

Section Five
Survivability

The Manpack radio is not survivable in its current configuration. The Army Research Laboratory Survivability/Lethality Analysis Directorate (ARL/SLAD) conducted a Step 4, cooperative analysis of the Manpack radio and Soldier Radio Waveform (SRW) network. The Army's Threat Systems Management Office, with assistance from ARL/SLAD, led a Step 5, adversarial assessment. The Threat Systems Management Office conducted electronic warfare via communications jamming of the SRW radios and unreliability jamming. The complete survivability evaluation is contained in the classified annex.

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Section Six
Recommendations

The Army should consider the following recommendations for the Manpack radio and Joint Enterprise Network Manager (JENM):

- Re-assess the use of the Soldier Radio Waveform (SRW) network as the primary voice and data network for company and platoon.
- Plan and conduct a follow-on operational test to conduct a full performance and reliability evaluation of the three Ultra-High Frequency Satellite Communications (UHF-SATCOM) waveforms (181B, 182A, and 183A).
- Plan follow-on operational testing for the Mobile User Objective System SATCOM capability when it is available and has completed developmental testing.
- Expand Manpack radio training to include leader training of tactics, techniques, and procedures on how networking radios function and how to operate a unit using networking communications.
- Clarify the system support plan for the Manpack radio in order specify the number of field service representatives (FSRs) that are planned.
- Plan and conduct more rigorous and operationally realistic developmental testing that stresses the radio and network to include—
  - Representative tactical vehicles
  - Dynamic dismounted and mounted mobility across representative operating conditions
  - Interoperability with mission command systems, such as Joint Battle Command – Platform (JBC-P)
- Investigate reducing the mission weight carried by Soldiers equipped with the Manpack radio.
- Investigate new packs to carry the Manpack radio that allow more comfort and increased heat dissipation.
- Assess means to more rapidly execute communications security (COMSEC) key changeover on SRW radios.
- Improve JENM preset and radio-loading procedures to support rapid changes in unit task organization.
- Develop test instrumentation to collect data on dismounted Manpack radios.